10/069926
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Josef PICKEL et al

Based on PCT/DE 01/ 02277

For: METHOD FOR PRODUCING BORES, IN PARTICULAR INJECTION PORTS IN INJECTION NOZZLES, AND APPARATUS THEREFOR

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination, please amend the above-referenced application as follows:

IN THE SPECIFICATION

Page 1, Between the title and paragraph [0001] insert the following:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 U.S.C. 371 application of PCT/DE 01/02277, filed on June 20, 2001.

[0000.6] BACKGROUND OF THE INVENTION

Replace paragraph [0001] with the following rewritten paragraph:

[0001] Field Of The Invention

Replace paragraph [0002] with the following rewritten paragraph:

[0002] The invention is directed to an improved method for producing bores in workpieces of electrically conductive material, in particular injection ports in injection nozzles of fuel injection systems for motor vehicles.

Between paragraphs [0002] and [0003] insert the following:

[0002.5] Description Of The Prior Art

Replace paragraph [0003] with the following rewritten paragraph:

[0003] In one known method of the type defined above, for producing bores by means of spark erosion, a thin electrode, also called an erosion wire, is placed against the workpiece. In spark erosion, by chronologically separate electrical discharges between the erosion wire and the workpiece, material of the workpiece is increasingly removed, in the course of which the erosion wire also wears down. The discharges are effected via energy storing means with voltages of more than 20 V; the voltage, current, discharge frequency and pulse length are adapted to the drilling task (Dubbel, Taschenbuch für den Maschinenbau [Mechanical Engineering Handbook], volume 2, 13th Edition, page 669). For drilling conical bores, the electrode is tapered conically toward its free end, so that a conicity of the bore hole with a diameter that decreases in the direction of the machining feed is attainable.

Replace paragraph [0004] with the following rewritten paragraph:

[0004] SUMMARY OF THE INVENTION

Page 2, Delete paragraph [0006]:

Page 3, Delete paragraph [0008]:

Replace paragraph [0009] with the following rewritten paragraph:

[0009] BRIEF DESCRIPTION OF THE DRAWINGS

Replace paragraph [0010] with the following rewritten paragraph:

[0010] The invention is described below in further detail in terms of an exemplary embodiment shown in the drawings. Shown are:

Page 4, replace paragraph [0012] with the following rewritten paragraph:

[0012] Figs. 2 and 3, each, an erosion wire of the apparatus of Fig. 1, in two different vibration modes; and

Replace paragraph [0014] with the following rewritten paragraph:

[0014] DESCRIPTION OF THE PREFERRED EMBODIMENTS

Page 7, Replace paragraph [0021] with the following rewritten paragraph:

[0021] In the exemplary embodiment of Fig. 1, the actuators 14, 15 are embodied as so-called piezoelectric stacks 17, 18. In each piezoelectric stack 17 and 18, a plurality of piezoelectric elements 23 are disposed, contacting one another, in the direction of their change in length. On the counterpart face of the fastening unit 13, which is remote from the engagement face of the respective piezoelectric stack 17, 18, one end of a compression spring 19 and 20, respectively, is braced, whose other end rests on a stationary abutment 21 and 22, respectively. When an alternating voltage of amplitude U is applied to the piezoelectric stack 17 or 18, the piezoelectric stack 17 or

18 undergoes a change in length in the direction of the x or y axis, so that the fastening unit 13 is excited to execute an oscillating motion, on the one hand in the direction of the x axis and on the other in the direction of the y axis. The vibration stroke is dependent on the amplitude U of the alternating voltage, and the vibration frequency is dependent on the frequency f of the alternating voltage. The compression springs 19, 20 assure a reliable, non-positive contact of the piezoelectric stacks 17, 18 with the fastening unit 13.

Page 8, After paragraph [0022] insert the following new paragraph:

[0023] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

Page 9, Line 1, delete "Claims" and insert --"We Claim"--.

IN THE CLAIMS

Please cancel claims 1-10 and add new claims 11-30.

11. A method for producing bores in workpieces of electrically conductive material, in particular injection ports (11) in injection nozzles (10) of fuel injection systems for motor vehicles, the method comprising, removing material in the workpiece forming the counterelectrode in a targeted way by spark erosion by means of an erosion wire (12) forming as electrode,

actively exciting the erosion wire (12) to a defined vibration,

and establishing the form of vibration by targeted variation of the vibration excitation in accordance with the desired bore hole shape.

12. The method of claim 11 wherein the vibration excitation of the erosion wire (12) is performed on one end (122) of the wire.

13. The method of claim 12 wherein the vibration excitation of the erosion wire (12) is performed separately in two orthogonal axes (x, y) located in the same plane, and that to attain the desired form of vibration of the erosion wire (12), the frequencies and the ratio of frequency to amplitude of the two vibration excitations as well as the phase displacement between the two vibration excitations in both orthogonal axes are controlled.

14. The method of claim 13 wherein, to attain a bore hole of circular cross section, the vibration excitations in the two orthogonal axes (x, y) are performed with the same amplitude and with a phase displacement ($\Delta\phi$) of 90°.

15. The method of claim 13 wherein, to create a bore hole of elliptical cross-sectional area, the vibration excitations in the two orthogonal axes (x, y) are performed with different amplitudes and with a phase displacement ($\Delta\phi$) of 90°.

16. An apparatus for performing the method of claim 13 wherein the end (122) of the erosion wire (12) is received in a fastening unit (13),wherein the fastening unit (13) is guided displaceably along two orthogonal axes (x, y) oriented transversely to the longitudinal axis of the erosion wire (12), and wherein two actuators (14, 15) engage the fastening unit (13) for separate oscillating displacement of the fastening unit (13) along the two orthogonal axes (x, y).

17. An apparatus for performing the method of claim 12 wherein the end (122) of the erosion wire (12) is received in a fastening unit (13),wherein the fastening unit (13) is guided displaceably along two orthogonal axes (x, y) oriented transversely to the longitudinal axis of the erosion wire (12), and wherein two actuators (14, 15) engage the fastening unit (13) for separate oscillating displacement of the fastening unit (13) along the two orthogonal axes (x, y).

18. An apparatus for performing the method of claim 13 wherein the end (122) of the erosion wire (12) is received in a fastening unit (13),wherein the fastening unit (13) is guided displaceably along two orthogonal axes (x, y) oriented transversely to the longitudinal axis of the erosion wire (12), and wherein two actuators (14, 15) engage the fastening unit (13) for separate oscillating displacement of the fastening unit (13) along the two orthogonal axes (x, y).

19. The apparatus of claim 16 wherein the actuators (14, 15) include piezoelectric elements (23), which upon application of an alternating voltage undergo a defined change in length in one direction and the other.

20. The apparatus of claim 17 wherein the actuators (14, 15) include piezoelectric elements (23), which upon application of an alternating voltage undergo a defined change in length in one direction and the other.

21. The apparatus of claim 18 wherein the actuators (14, 15) include piezoelectric elements (23), which upon application of an alternating voltage undergo a defined change in length in one direction and the other.

22. The apparatus of claim 19 wherein the actuators (14, 15) are each formed by a piezoelectric stack (17, 18), in which a plurality of piezoelectric elements (23) are disposed in contact with one another in the direction of their change in length.

23. The apparatus of claim 20 wherein the actuators (14, 15) are each formed by a piezoelectric stack (17, 18), in which a plurality of piezoelectric elements (23) are disposed in contact with one another in the direction of their change in length.

24. The apparatus of claim 21 wherein the actuators (14, 15) are each formed by a piezoelectric stack (17, 18), in which a plurality of piezoelectric elements (23) are disposed in contact with one another in the direction of their change in length.

25. The apparatus of claim 16 wherein the actuators (14, 15) are embodied as electromechanical vibration motors.

26. The apparatus of claim 17 wherein the actuators (14, 15) are embodied as electromechanical vibration motors.

27. The apparatus of claim 18 wherein the actuators (14, 15) are embodied as electromechanical vibration motors.

28. The apparatus of claim 16 wherein the actuators (14, 15) are embodied as ultrasonic transmitters.

29. The apparatus of claim 17 wherein the actuators (14, 15) are embodied as ultrasonic transmitters.

30. The apparatus of claim 18 wherein the actuators (14, 15) are embodied as ultrasonic transmitters.

IN THE ABSTRACT

Please substitute the attached rewritten Abstract of the Disclosure for the abstract as originally filed.

REMARKS

The above amendments are being made to place the application in better condition for examination.

Entry of the amendment is respectfully solicited.

Respectfully submitted,

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ABSTRACT OF THE DISCLOSURE

A method for producing bores in workpieces of electrically conductive material, in particular injection ports (11) in injection nozzles (10) is disclosed, in which method, by means of an erosion wire (12) forming an electrode, material in the workpiece forming the counterelectrode is removed in a targeted way by spark erosion. To produce bores of different cross-sectional shapes and/or a varying cross-sectional area over the length of the hole, the erosion wire (12) is actively excited to a defined vibration, and the form of vibration is established by targeted variation of the vibration excitation in accordance with the desired bore hole shape. A preferred apparatus for performing the method has a fastening unit (13), which receives the end (122) of the erosion wire (12) and which is driven by two actuators (14, 15) to execute a separate oscillating displacement along an x axis and a y axis (Fig. 1).

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION

Page 1, Between the title and paragraph [0001]:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 U.S.C. 371 application of PCT/DE 01/02277, filed on June 20, 2001.

[0000.6] BACKGROUND OF THE INVENTION

Paragraph [0001] has been amended as follows:

[0001] ~~Prior Art~~ Field Of The Invention

Paragraph [0002] has been amended as follows:

[0002] The invention is ~~based on a~~ directed to an improved method for producing bores in workpieces of electrically conductive material, in particular injection ports in injection nozzles of fuel injection systems for motor vehicles~~, as generically defined by the preamble to claim 1~~.

Between paragraphs [0002] and [0003]:

[0002.5] Description Of The Prior Art

Paragraph [0003] has been amended as follows:

[0003] In one known method of the type defined above, for producing bores by means of spark erosion, a thin electrode, also called an erosion wire, is placed against the workpiece. In spark erosion, by chronologically separate electrical discharges between the erosion wire and the workpiece, material of the workpiece is increasingly removed, in the course of which the erosion wire also wears down. The discharges are effected

via energy storing means with voltages of more than 20 V; the voltage, current, discharge frequency and pulse length are adapted to the drilling task (Dubbel, Taschenbuch für den Maschinenbau [Mechanical Engineering Handbook], volume 2, 13th Edition, page 669). For drilling conical bores, the electrode is tapered conically toward its free end, so that a conicity of the bore hole with a diameter that decreases in the direction of the machining feed is attainable.

Paragraph [0004] has been amended as follows:

[0004] ~~Advantages of the Invention~~ SUMMARY OF THE INVENTION

Page 2, Deleted paragraph [0006]:

[0006] ~~By the provisions recited in the other claims, advantageous refinements and improvements to the method defined by claim 1 are possible.~~

Page 3, Deleted paragraph [0008]:

[0008] ~~An advantageous apparatus for performing the method of the invention is defined by claim 4. Advantageous embodiments of the apparatus are recited in claims 5-7.~~

Paragraph [0009] has been amended as follows:

[0009] ~~Drawing~~ BRIEF DESCRIPTION OF THE DRAWINGS

Paragraph [0010] has been amended as follows:

[0010] The invention is described below in further detail in terms of an exemplary embodiment shown in the ~~drawing~~ drawings. Shown are:

Page 4, Paragraph [0012] has been amended as follows:

[0012] Figs. 2 and 3, each, an erosion wire of the apparatus of Fig. 1, in two different vibration modes; and

Paragraph [0014] has been amended as follows:

[0014] ~~Description of the Exemplary Embodiment~~ DESCRIPTION OF THE PREFERRED EMBODIMENTS

Page 7, Paragraph [0021] has been amended as follows:

[0021] In the exemplary embodiment of Fig. 1, the actuators 14, 15 are embodied as so-called piezoelectric stacks 17, 18. In each piezoelectric stack 17 and 18, a plurality of piezoelectric elements 23 ~~is~~ are disposed, contacting one another, in the direction of their change in length. On the counterpart face of the fastening unit 13, which is remote from the engagement face of the respective piezoelectric stack 17, 18, one end of a compression spring 19 and 20, respectively, is braced, whose other end rests on a stationary abutment 21 and 22, respectively. When an alternating voltage of amplitude U is applied to the piezoelectric stack 17 or 18, the piezoelectric stack 17 or 18 undergoes a change in length in the direction of the x or y axis, so that the fastening

unit 13 is excited to execute an oscillating motion, on the one hand in the direction of the x axis and on the other in the direction of the y axis. The vibration stroke is dependent on the amplitude U of the alternating voltage, and the vibration frequency is dependent on the frequency f of the alternating voltage. The compression springs 19, 20 assure a reliable, non-positive contact of the piezoelectric stacks 17, 18 with the fastening unit 13.

Page 8, After paragraph [0022]:

[0023] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

Page 11, Abstract

~~Abstract~~ **ABSTRACT OF THE DISCLOSURE**

A method for producing bores in workpieces of electrically conductive material, in particular injection ports ~~(11)~~ in injection nozzles ~~(10)~~ is disclosed, in which method, by means of an erosion wire ~~(12)~~ forming an electrode, material in the workpiece forming the counterelectrode is removed in a targeted way by spark erosion. To produce bores of different cross-sectional shapes and/or a varying cross-sectional area over the length of the hole, the erosion wire ~~(12)~~ is actively excited to a defined vibration, and the form of vibration is established by targeted variation of the vibration excitation in accordance with the desired bore hole shape. A preferred apparatus for performing the method has a fastening unit ~~(13)~~, which receives the end ~~(122)~~ of the erosion wire ~~(12)~~ and which is driven by two actuators ~~(14, 15)~~ to execute a separate oscillating displacement along an x axis and a y axis ~~(Fig. 1)~~.